About the relations between Management Accounting Systems, Intellectual Capital and Performance

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Abstract— **The present study is focused on the contribution of management accounting systems (MAS) in the development of intellectual capital (IC). Based on empirical evidence that supports the proposition that the value creation process is strongly associated to the level of IC, the study also examines the mediating effect of MAS on performance through their positive direct effect on IC. These relationships were consolidated into a model and empirically tested with data from 281 Portuguese firms using the Structural Equation Modeling (SEM). The findings show that six out of nine hypothesized relationships were supported by data with positive and significant causal links between MAS and the human and structural dimensions of IC. Results confirmed the conceptual validity of the circular model for the interactions among the three IC dimensions. Results also showed a positive and significant direct effect of structural capital on performance. Overall, the results confirmed the validity of the proposed model and contributed to the literature on the role of MAS in supporting the development of the IC.**

Keywords-Management accounting systems; intellectual capital; performance.

I. INTRODUCTION

Since the discussion on the issue of IC was brought to the forefront of organizational issues of most interest in the last two decades, the notion of organizational knowledge is remarkably enhanced. Developments so far focused attention on the knowledge of individuals and on the organization's role in establishing the necessary actions so that it found the conditions to grow and expand, as this was seen as the main way of creating and expanding organizational knowledge. Without granting the importance of human capital (HC), the notion of organizational knowledge has evolved to also consider the structural capital (SC) and the relational capital (RC), as well as the relations and collective effects of such elements that generally are seen as IC constituents.

The evolutionary process of MA is related to the changes on organizational paradigms [3]. This process is a way that allows MA to accomplish the conditions to an effective response to the theoretical, technical and practical issues posed by the new paradigms. The current MA paradigm addresses the effective management of organizational resources and their relevance for the value creation process. Bhimani and Roberts [5] observed that accounting information enables different organizational activities to be classified uniformly and to be altered so that they become economically functional and managerially controllable. In practical terms, MA has the potential to become an imminent part of knowledge management (KM) activities. In this way, it is reasonable to consider the existence of complementarities between MA and the IC. The present study considers the existence of such complementarities, and it is focused on the contribution of MAS to the development of IC. The study also examines the mediating effect of MAS on performance through IC.

Despite the awareness that traditional accounting procedures influence behavior in organizations [28], some literature has shown how MAS should evolve in order to be able to fully address the challenges to manage IC, particularly through the adoption of a more strategic orientation and the use of specific frameworks such as BSC. However, the literature has also shown that many organizations, even those of more knowledge-intensive sectors, continue to rely on traditional systems and make use of them to manage IC [16] [26] [47]. As such, it would be interesting to have a general framework on how MAS currently in use in companies are able to promote the development of IC. In this context, the research has two main objectives: first, to develop and test a more complete framework of the relations between MAS, IC and performance, providing a broad overview of the process – despite of the existing literature addressing the relationship between MA and the IC [7] [16] [17] [36] [39] [46] [47] [52], this is the first study, of which authors are aware, that focuses specifically on the relationships between MAS and the three dimensions of IC (HC, SC and RC), as well as their effects on performance; second, to expand our understanding on the relationships between the focal variables, contributing to the expansion of the literature on accounting for IC [41].

II. A MANAGEMENT ACCOUNTING OUTLOOK ON IC

A. LiteratureRreview

The literature has suggested the development of MA and its instruments in order to comprehensively embrace IC.

Tayles et al. [46] concerns about the potential role of MA stressed the importance of strategic MA in supporting the measurement and management of IC. They contended that in order for MA to be of real strategic value, it must be possible to

identify and value, with some precision, the component elements of the generic IC of the company. Wingren [52] proposed a model that combines tangible and intangible measurement systems. The framework links the balanced scorecard and the IC in a structure that includes a tangible side that shows the strategic targets, the critical success factors and the measures needed to reach the targets in financial perspective, and a intangible side that shows the strategic targets, the critical success factors and the measures needed to reach the targets of expectations perspective. The framework also shows how MA content may move from a tangible and production-focused to a more intangible and knowledge-driven economy. Tayles et al. [47] developed a study with the purpose to examine whether, and in what way, managers perceive that the level and shape of IC influences MA practice. The study was conducted in Malaysian companies with different levels of IC. The results showed that IC does influence some MA practices for firms investing heavily in IC. The results also showed that the control style of these companies has a broader orientation, focusing on concerns for general effectiveness, quality, handling staff, and job effort, rather than a budget emphasis. Roberts [39] has developed an accounting-based concept of the knowledge production process based on the principle of connectivity. According to this approach, knowledge is an object that can be accounted for as well as open up for manipulation by accounting technologies. Accordingly, the MA focus is much more about managing connectivity, that is, the flows of knowledge transfer and the interdependencies of resources.

After several years of developments, it is clear from the literature that IC phenomenon has a strong human focus and that the MA perspective on IC should not overlap this fact [7] [16] [39] [41] [46]. Consequently, calls for a human resource perspective on MA have been made in order to provide management with accounting information on human resources. As Roberts [39] observed, developments in management control frameworks reveal an effort to integrate different functional perspectives, and to put HC in a wider context of interpretation. However, it is also clear that the broad activity of KM is not the sole responsibility of a single discipline, rather requires a confluence and a closer dialogue among various disciplines [5] [28] [39] [46], such as human resource, information systems and strategy. By other side, it is clear from the literature that KM involves the confluence of financial and nonfinancial methods and measures [7] [39] [47], which means that organizations will need to ensure some level of development of their MA and control systems to fully address to this issue. Finally, it is also clear that MA is an instrument part of KM activities [5] [21], and that much of the contribution of MA to the IC relies on its capacity to address the issue of KM and the issues of information, flows of information and interaction mechanisms it encapsulates. In the following sections, MAS will be described as elements of the managerial apparatus that managers may use to promote the activities that invoke knowledge, namely as information networks and as networks of relationships.

B. Conceptual Model and Hypothesis Development

Variable Explanation: The present study aims to relate MAS, IC and performance in order to identify causal relationships between variables. The categorization of MAS in relevant dimensions is common in MA research, allowing considering specific issues and objectives of MAS that a global perspective cannot capture. This research work makes use of six dimensions of MAS referred on the literature (See e.g. [1] [6] [12] [15] [26] [32] [33]), grouped in three categories: style of use of information provided by MAS, which consider the diagnostic and the interactive dimensions; type of information provided by MAS, which consider the aggregation and the integration dimensions; and type of decision supported by MAS, which consider the resource allocation and the performance evaluation dimensions. We are aware that these six dimensions are likely to capture the type of MAS in use and to give a suitable picture on how they are linked to the different dimensions of IC. For the purposes of present research, IC is the representation of the combined knowledge resources of the organization [39], which is largely the result of the use, dissemination, application and relationship of knowledge within organizations. There is a general consensus in the literature that human capital (HC), structural capital (SC) and relational capital (RC) are the components of the IC construct. HC embodies the knowledge, talent and experience of employees [10]. The essence of HC is individual knowledge, the intelligence of each organizational human element [18]. SC relates to organizational capability and reflects the organization´s ability to translate the innovation and the energy of its HC into organizational property and make use of that to create value. SC is the infrastructure that incorporates forms and supports HC, encouraging people to create and to share knowledge [20]. Finally, RC is the relational network between people and groups of people [39]. That is, RC of an organization concerns its internal and external contact networks through which information is transferred and knowledge is shared. It is within RC that an organization's HC gets connected to other organization's HC, combining diverse insights and interpretations into novel ways of perception and alternative modes of action [7]. As in the case of HC, RC is not owned by the organization, but it can take actions for its development, particularly in fostering connectivity between the (internal and external) elements essential to its formation. Each of these IC components on its own is useless. Rather, they work together in judicious combinations to ensure the use of IC in creating value. A review of recent literature related to organizational performance left a clear lack of consensus as to the meaning of the concept. However, in a consistent and growing way, literature has been advocating the use of several indicators to measure performance, either because financial measures have certain limitations arising from their very nature or because in certain circumstances it may be desirable a non-financial expression of a particular organizational reality, or even because the very complex organization imposes certain restrictions on representations of the underlying quantifier frameworks, simultaneously highlighting the benefits that derive from the use of multiple indicators in order to obtain a multidimensional view of performance [23] [42] [45] [49]. So, in this work performance is defined as a complex variable with

multiplicity of factors contributing to the level of global performance at any point of time [35].

Hypothesis Development: the perspective that analyzes how MAS contributes to the development of IC argues that MAS act as a tool to focus the attention of management and allow understanding of specific aspects that are crucial in the value creation process [17] [44] [46]. MAS offer a set of management indicators in addition to financial measures, established according to the strategy and objectives specific to each organization, allowing the identification of gaps for exploitation of new knowledge, the accommodation of existing knowledge and the engagement of new knowledge to the organization's knowledge portfolio [21] [36]. Therefore, it is reinforced the idea that MAS provide the conditions for knowledge being converted into HC, SC and RC. So, we formulated the following hypothesis:

H1: MAS support the development of IC through the development of HC (H1.1), SC (H1.2) and RC (H1.3).

(H1.1) The process of knowledge creation has a strong focus on human resources, as it is based on the interaction and transfer in the tacit dimension, even before the explicit dimension being raised. On the role of MAS in the process, this can be reflected both in the capacity to provide information that enables the development of HC as in capturing (encoding) the actual HC generated within the organization and thereby provide the development of other IC dimensions. (H1.2) The elements that support SC are usually very specific to each organization and its value for organizations depends on the particular contribution to their objectives. SC is a set of procedures, standards, systems, routines, rules, etc, that together form the organizational system (structure and processes). Accounting, as a rule-based management technology, is a natural element of SC [39]. Thus, one would expect that the very development of MAS may contribute to increase the SC, being sure that this will occur differently in each organization and is inexorably dependent, at least in part, of the complementariness produced with the organizational structure, including the procedures, the routines and other information systems. (H1.3) The RC is owned by the collective, but has no formal property or transactional rights associated. The role of the organization is limited to the establishment of conditions for its development, including the design and implementation of the appropriate systems of motivation and the creation of the conditions for exchanges or relationships [39]. In short, the establishment of the coordination mechanisms that allow parties with complementary and interdependent knowledge and skills to find the interaction conditions, in which MA and control systems play an important role. Wickramasinghe and Alawattage [51] referred to the accounting and control systems as enabling institutions, which may contribute to legitimize these relations, making them more flexible and more interactive. Bjurström and Roberts [7], by other side, stressed that for an organization to benefit from RC, it will attempt to bring these relations into its realm of control, either by controlling its infrastructure, or by controlling its processes, for example by generating criteria for participation or rewards. So, if existing MAS contemplate the necessary mechanisms to coordinate connectivity, which includes enabling it and control it, then it is expected a positive direct relationship between MAS and RC.

The IC is a phenomenon of interactions [14] [31] [40]. However, one of the least studied features concerning the creation and development of IC is precisely the potential complementarities between its components and the resultant effects [31]. A dynamic view of the IC considers an integrated view of all IC elements, which means considering the effects of different dimensions on each other. Investment decisions in IC must take into account this dynamic of IC and assess the interdependencies between its components; on the other hand, the levels of interdependence among the components of IC change continuously, so the anticipation of these mutations is a key issue since it allows (re)direct the investment efforts to new priorities; finally, it should be noted that the best way of developing a component of the IC is not always achieved through direct investment in this component, since the effects of interdependencies between the components of the IC can cause the best way to develop a component is through indirect investment, i.e., by investing in other component [17]. There isn't, therefore, separation in each of the dimensions of the IC, so it is difficult to refer to transactions that affect exclusively a single dimension. The recognition of these interdependencies will develop best management practices that might affect directly certain dimensions and are likely to influence other dimensions. So, we formulate the following hypothesis:

H2: There are interactions between different dimensions of IC and these interactions are translated into positive effects in terms of development of each dimension, thus contributing to the overall development of organizational IC

In developing the conceptual model to be considered in this research the dynamic relationship between the IC dimensions follows Martinez-Torres [31] who proposed a circular model in which are identifiable direct relations between the HC and SC (H2.1), between the SC and RC (H2.2), and between the RC and HC (H2.3). The proposed model also includes indirect relationships between the components, to the extent that the direct effect of one dimension (e.g., HC) in other (SC) will be reflected on the direct effect that the last one produces on the third component (RC). In our view, this is the structure that best fits the process of knowledge production and the integration of knowledge as organizational IC.

The study of HC, SC and RC, as well as its interactions and interdependencies, is important not only to understand their impact in terms of development of IC as a whole, but also to understand their effects on certain organizational variables, such as the performance. The literature related to the IC suggests that it can provide a competitive advantage over competitors, due to its idiosyncratic nature, turning it into a strategic element [38]. This condition is considered mainly in terms of the organization's ability to achieve superior performance levels. Considering the above, it is possible to assert not only the effect of IC on performance but also that this effect takes place in different ways and with different implications. Some of the studies that analyzed the relations between the IC and performance do not report empirical evidence on the existence of causal relationships between

certain dimensions of IC and the performance (See e. g. [34]). The proposed model considers the existence of causal links between all IC dimensions and performance. This decision is supported by (i) the theoretical framework that points to the existence of these relations and the empirical evidence reported in some research, as stated above, (ii) the absence of empirical evidence suggesting that a single construct -- HC, SC or RC – is truly the driver of organizational performance or whether it requires a combination of them [10], and (iii) the fact that causal relationships can be more substantial in certain industries, or even dependent on the country where the organizations are located [9]. We must also consider the configuration of the relations between the dimensions of IC as well as their amplitude, which differs more or less significantly among organizations. Moreover, the model considers the indirect effects of MAS on performance, via IC, and these relationships have not been adequately studied so that it would be possible to infer their effect on Portuguese companies. So, we formulate the following hypothesis:

H3: There are direct positive relationships between the different IC dimensions and organizational performance

III. Methodological Issues

A. Sample Procedure

The pool of target respondents included high-level managers of firms with more than 100 and less than 500 employees considering all sectors of activity. A sample was drawn from the Belém Data Base, a Portuguese firm database developed by the Portuguese institute of statistics (Statistics Portugal), covering all economic sectors. The focus on all sectors of activity is likely to provide a cross-sectional image and a more global perception on the effects of the relationships between variables in Portuguese firms, thereby increasing the generalization of results [37]. We focused on entities with large number of employees that (i) have MAS formally implemented and (ii) these systems present a certain extent and some degree of sophistication. The final usable database contained 6 428 records of companies. Data were collected using a mailed questionnaire survey. The questionnaire was sent to high-level managers. The instrument consists of six questions with multiple items, measured on a 7-point Likert scale. The first three questions relate to the characterization of MAS, considering the style of use, the type of information provided and the type of decision supported by the system. The fourth question concerns the degree of implementation of a number of dimensions related to human, structural and relational capabilities. The fifth issue concerns to the degree of compliance with a set of objectives for the company. The final sample includes 281 companies, so that the overall usable response rate was 17.2%, a suitable value considering the nature and extension of the information requested and the target population [29]. Regarding the representativeness of the final sample, there were no significant differences on the distribution of firms by sector and employees. Concerning to the position, responses were grouped as follows: president/CEO (40.6%), chief financial officer (28.5%), controller (10.7%), chief account officer (9.9%), and other position (10.3%). Considering the number of employees, 76.8% reported a number of employees in the range 100-249 and 23.2% in the range 250-499. Finally, 43.7% of companies reported a sales volume not exceeding €15 million (M), 34.7% in the range €15M-€40M, 15.5% in the range €40M-€100M and 6.1% exceeding €100M.

B. Variable Measurement

The construction of the questionnaire was supported in instruments developed by other authors. Adjustments were performed in order to meet the objectives of the work. Feedback from the pretest also leaded to some adjustments. The framework for measuring the style of use of MAS was based in a section of the questionnaire developed by Naranjo-Gil and Hartmann [33], which present the main features of an interactive or diagnostic use of MAS. Regarding the type of the information provided by MAS, the measurement was based on the questionnaire applied by Bouwens and Abernethy [12], an adapted version of the questionnaire developed by Chenhall and Morris [15] to investigate the perceived usefulness of four dimensions of MAS – *scope*, *timeliness*, *aggregation* and *integration* - for the operational decision making process. The structure proposed by Bouwens and Abernethy [12] for aggregation and integration dimensions comprised some changes to the instrument previously defined by Chenhall and Morris [15] in order to increase the level of generalization of the instrument and to grasp the importance of information provided to manager in making operational decisions rather than the usefulness or the use of the information, as advocated by the initial instrument. The extent of how MAS are used to support decision making draws again on the questionnaire developed and applied by Naranjo-Gil and Hartmann [33].

The degree of implementation of all dimensions related to human, structural and relational capabilities do not reproduce any other instrument developed and applied in previous studies, although its structure was supported by the extensive bibliography and some empirical research (e.g. [9] [43]).

Performance was measured using a slightly modified version of the Scott and Tiessen [42] questionnaire to explore the incidence and importance of measuring the performance of management teams. The original structure was simplified and respondents were asked for each of the three financial categories (cost, sales and profitability) and the five non-financial categories (productivity, quality, service, innovation and personnel) as a whole, using the original items as benchmarks to determine the scope of each of the seven categories. This procedure fulfilled the objectives of the work and avoided problems concerned to the validation of the measurement scale, most likely to occur when a large number of items are used in the measurement of a construct. The arrangement of different categories follows the original questionnaire. However respondents were asked to rate the degree of fulfillment of each target taking the last three years as reference, thus allowing for a dynamic perspective of performance measurement and simultaneously setting up a mechanism to prevent circumstantial effects on the process.

C. *Estimation and Analysis of the Conceptual Model*

In order to test the proposed model, a SEM procedure with AMOS was applied. We have followed the two-step approach. The advantages of this procedure have been extensively discussed by Anderson and Gerbing [2] and are linked with the possibility of acquiring a body of knowledge concerning to the variables that compose the final model.

A reliability analysis - Cronbach α - was performed to the set of indicators for each construct in order to assess the degree of consistency of measurements of variables. Results showed the existence of three constructs that despite surpassing the recommended value of 0.7 [25] proved to be less reliable due to the existence of items whose values pointed to their exclusion. The final figures far outweigh the recommended value of 0.7, indicative of good internal consistency, thus ensuring the conditions for accepting the reliability and unidimensionality of the measurement scales [8]. Additionally, we assessed for convergent validity and discriminant validity. In assessing for convergent validity we examined the individual item reliability, the composite reliability and the average variance extracted (AVE) [4] [24]. The item reliability was assessed by the item factor loading onto the underlying construct. The composite reliability was estimated to evaluate the internal consistency of the measurement model. A recommended threshold value for composite reliability is 0.7 or more. The AVE measures the amount of variance that is captured by the construct in relation to the amount of variance due to measurement error [24]. Values of AVE greater than 0.5 are considered adequate for convergent validity [4]. Results showed that both the AVE and the composite reliability met the recommended threshold values, indicating adequate convergent validity. Discriminant validity measures the extent to which the constructs are distinct. Discriminant validity is present when the square root of the AVE of a construct is larger than the correlation between that construct and the other constructs [24]. A single violation of the criterion was observed with respect to the relation of the constructs resource allocation and performance evaluation. Overall, discriminant validity appears adequate.

Confirmatory factor analysis (measurement model): for this purpose we considered two confirmatory factor analysis models (See [19]) - a model consisting of the exogenous constructs (Model A) and the other consisting exclusively of the endogenous constructs (Model B), i.e., those constructs that have their causal antecedents specified within the model under consideration [2]. This kind of formalization is intended to analyze the set of relations between observable indicators and latent variables, and evaluate the relationships between them. The model fit was assessed using indices from various categories of fit criteria (See e.g. [8] [13]), thus overcoming the problem related to the lack of a better fit index about the model fitting [13] [22] [25]. Regarding to the question of which indexes to choose from each category, we follow Byrne's [13] recommendations that pointed to the need to consider the extent to which indices could be affected by factors such as the simple size, the model complexity and other underlying process estimation procedures. The widespread use of some indicator over others was also considered. So, in order to have a measure of the overall model fit, we chose to use the $\chi 2$ with degrees of freedom and p-value, the Jöreskog and Sorbom's goodness-of-fit index (GFI) and the Adjusted Goodness-of-fit index (AGFI), a modified version of GFI that takes into account the degrees of freedom and that considers the concept of parsimony through a penalty by the inclusion of additional parameters. To measure the incremental fit, we considered the Tucker-Lewis Index (TLI) and the Bentler's comparative fit index (CFI), a modified version of Normed Fit Index (NFI) that also takes into account the degrees of freedom [8]. Finally, the Root Mean Square Error of Approximation (RMSEA), along with its associated confidence interval, and Akaike's Information Criterion (AIC) were used to measure model parsimony. Parsimony adjusted measures introduce a penalty for complicating the model by increasing the number of parameters in order to improve the fit [8] [13] [25].

IV. RESULTS

As mentioned, we initially considered two models for confirmatory factor analysis in order to evaluate and validate the measurement model. Model A is a recursive model, since no variable in the model has an effect on itself. The estimating process resulted in a non-admissible solution. An iterative process was initiated based on information provided by modification indices, through which, some relations became free in the model, allowing an acceptable fit. The chi-square was significant ($\chi 2$ =397.679; df=241; p=0.000), suggesting that the fit of the data is not entirely adequate. However, due to over-sensibility of chi-square test to the model complexity (large number of variables) and to sample sizes greater than 200 [25], we also took into consideration the ratio $\chi 2$/df. The value of $\chi 2$/df was 1,650, below the recommended maximum of 3.00. GFI, TLI and AGFI indices range from 0 (poor fit) to 1 (perfect fit), with an acceptable minimum level of 0.90, while CFI index ranges from 0 (poor fit) to 1 (perfect fit), with an acceptable minimum level of 0.95. All indices were near or above to the minimum recommended levels, denoting that the hypothesized model fits the data reasonably: GFI=0.899; TLI=0.964; AGFI=0.864; CFI=0.971. The RMSEA value was 0.048 (values below 0.05 indicate good fit), while the associated confidence interval (which ranges from 0.040 to 0.057) denotes a good precision of the RMSEA value in reflecting model fit in the population. Finally, the AIC value of 565.679 was less than the value for the Saturated Model (650.000), as it should be. Model B consists of the endogenous constructs of the conceptual model proposed: HC, RC, SC and performance. The model is non-recursive, as the schema of causal relationships in the model admits the existence of indirect effects of some variables on itself. The estimation process also resulted in a non-acceptable solution, since the values for the fit quality measures are below the minimum recommended levels. The final model, which considers the elimination of the link between HC and performance and between RC and performance, has been stabilized after an iterative process based on information provided by modification indices, allowing an acceptable fit: $\chi 2$=193.078 (df=132) p=0.000; $\chi 2$/df=1.463; GFI=0.932; TLI=0.967; AGFI=0.901; CFI=0.975; RMSEA=0.041 (CI: 0.027; 0.053); AIC (Saturated Model)=309.078 (380.000).

Then we proceeded to estimate the global model in order to test the research hypotheses. The results showed a significant chi-square ($\chi2$=1139.672; df=835; p=0.000), suggesting that the fit of the data to the hypothesized model is not entirely adequate. However, the value of $\chi2$/df was 1.365, below the recommended maximum of 3.00. Both GFI (0.854) and AGFI (0.826) were slightly below the recommended level of 0.90, while TLI (0.975) and CFI (0.962) were better than the recommended levels of 0.90 and 0.95, respectively, suggesting a reasonable fitting of the hypothesized model to the data. The value of RMSEA (0.036) suggests a good fit, and the associated confidence interval (0.031; 0.041) a good precision of that value in reflecting the model fit in the population. Finally, the value of AIC index (1449.672) was less than the value for the Saturated Model (1980.000), denoting a satisfactory compromise between goodness of fit and parsimony. As mentioned, the estimation of the model was based on maximum likelihood estimation, the most common method in modeling processes with structural equations. It should be noted, however, that a basic assumption inherent in this procedure refers to the multivariate normality of the data. As Byrne [13] stated, the lack of multivariate normality may result in an unrealistic increase of the chi-square obtained by maximum likelihood estimation, which can lead to changes in the proposed model in order to obtain best fits, to convergence problems, to underestimated values of some fit indices or even to an artificial reduction of the standard errors that results in misinformation regarding the statistical significance of the analysis outcomes.

The use of bootstrap is a procedure to deal with the issue of non-normality of data. With this procedure, the estimation of parameters and standard errors are no longer calculated on statistical assumptions, to be based on empirical observations [25]. Model is estimated for each new sample, so that the final estimates corresponding to the average estimates of all samples. The final estimates are obtained directly from multiple estimations of the model over different samples. The process was carried out by testing for 100, 250, 500 and 1000 bootstrap samples. This process allowed us to see how the results evolve with the increasing of the number of bootstrap samples. The first information of interest refers to the number of usable bootstrap samples obtained from the process, allowing verifying to what extend it matches the number initially defined for analysis. Reports for the four analyses showed that, in any case, the corresponding number of usable bootstrap samples was obtained. Reports also provided several estimates that should be compared with previous estimates for original sample. Results for the analysis of 100 samples showed a p-value = 0.386, which means that the model should not be rejected. The tests for 250, 500 and 1000 samples led to the same conclusions (p-values of 0.311, 0.259 and 0.266, respectively). So we can say that the estimated causal model is valid and representative of the reality we want to describe.

V. Discussion

The idea of MAS as elements of organizational structure that favors the development of IC has been highlighted in the literature, namely as tools of communication, dissemination and interpretation of information that support the interaction mechanisms to the creation, transmission and integration of knowledge. On this basis, we established the preposition that suggests the existence of direct links between MAS and each of the dimensions of IC. The results of the estimation process showed a positive and statistically significant effect of MAS on HC, thus validating the research hypothesis formulated. This finding is relevant in that it emphasizes the importance of MAS in supporting the processes of interaction and motivation as well as the process of adaptation they promote – or give rise – in influencing the perception of individuals with regard to phenomena that occur in the internal and external environment, concepts that are determinants of the incremental or generative knowledge. As Bontis [9] stated, the stock of HC will be deteriorated if not constantly supported and nurtured.

Results also showed a positive and statistically significant effect of MAS on SC. This is relevant considering the prominent role of SC as support structure of the organizational systems and processes. Through this direct effect MAS also contribute to increase internal efficiency, an indicator of the development of SC. The relationship describing MAS as direct causal antecedent of the RC was positive but not statistically significant, thereby not allowing support the hypothesis. It certainly has something to do with the difficulties in formalizing the kind of links that support, give expression and value this dimension of IC, and that literature describes as heavily dependent on their durableness. Although MAS are likely to sponsor the relational schemas inherent to the development of RC, supporting and/or legitimizing them effectively [51], the structures and the systems of communication that characterize many of the social networks that the company establishes and fosters with external entities may be substantially different from the organizational structures under which the development of MAS has been based over time, delineating its potential contribution. Another possible explanation is that, as highlighted before, the exchange and interactions of the relational groups creating new knowledge are very much out of reach for management. As Bjurström and Roberts [9] observed, once the relational groups have started working, the internal human dynamics of the group take over, and follow the knowledge production's own logic. In conclusion, the systems currently in use in organizations are not fully capable of acting on the RC, which gives reason to those [7] [21] [26] [39] advocating a more focused MA on relationships. Overall, the results reinforce the prominence of MAS in the process, either by supporting the processes of interaction and motivation that enable the HC development through the generative knowledge, either by increasing internal efficiency that direct and indirectly contributes to the development of SC. The conversion of SC in value creation occurs through the use of information technology processes and organizational structure to manage knowledge in a systematic way. Therefore, the two moments in terms of value creation invoked by Roos et al. [40] or Roberts [39] are highlighted: investment, in terms of creating the background conditions (processes, systems, routines, culture, etc.) that encourages the development of mechanisms for interaction and relationships that lead to the formation new knowledge (HC), and appropriation, i.e., integration and formalization of this knowledge in creating new organizational capabilities (SC), in a cycle that regenerates itself.

Although there is no consensus in the literature regarding the type and form of relations between IC dimensions, as noted before, it is clear that IC is the expression of the collective effects arising from dependencies and interdependencies between them [9] [31]. The finding of a direct positive and significant link of HC on SC shows, as formulated, that HC is the direct precursor of SC. It also represents the capacity of organization to codify, retain and internalize a kind of tacit knowledge and highly difficult to formalize. The estimation process can also support the hypothesis of a direct relationship of SC in the development of RC, to reveal a statistically significant positive effect. This shows the importance of SC in supporting the relational schemas that underlie the development of RC. Finally, the explanatory power of RC on HC is also asserted through a positive and statistically significant link. Together, the positive and statistically significant effects found in the relationships between HC, SC and RC confirm the validity of the inner circular model of the proposed conceptual model, reinforcing previous research findings [31]. As mentioned, in addition to direct effects related to the explicit outlined relations, a number of indirect effects inherent to the circular model were identifiable. The results showed the existence of positive indirect effects, confirming that the analysis and interpretation of IC, which is closely based on interactions and internal flows [9] [31] [40], should not neglect the indirect relationships between its dimensions. It should be noted that confirmation of the structure of relationships to the IC dimensions also generates a disseminating effect of the impact of MAS. In other words, the effects of MAS in each IC dimensions are projected beyond those that are given by the supposed direct relationship, regardless of its statistical significance. Thus, in addition to the direct effects resulting from the structure of relationships between MAS and IC dimensions, a number of indirect effects should be considered. Despite the low direct impact of MAS on the development of IC, suggesting that a significant proportion of variance remains unexplained, the cumulative effect - direct and indirect - is far more substantial. These results are consistent with the literature which is sufficiently explicit as to the confluence of factors which contribute to the development of IC, being MAS just another of these formative elements.

The importance of developing the IC can be assessed through direct effects on organizational performance. However, the models developed and tested to evaluate the effects of different dimensions of IC on performance have provided conflicting results. As such, the general proposition formulated assumes the existence of direct and positive effects of each of the three dimensions of IC on performance. Results of the estimation process do not allow supporting that proposition because, although positive, the effects of HC and RC on performance were not statistically significant. Conversely, the relationship between SC and performance was positive and statistically significant, which is in line with some research (e.g. [9] [11] [14] [34]) and proves the importance of SC as a repository of organizational capabilities and memory [50]. Considering the positive and statistically significant direct link of MAS on SC, as noted, we may conclude that MAS can impact positively on performance through the mediating effect on SC, which is in line with prior investigation [16] [17]. The explanatory power of HC and RC on performance occurs only indirectly, through the successive effects between IC dimensions resulting from the circular model.

CONCLUSIONS

The study contributes to understanding the relationships between MAS, IC and performance in several ways: (i) the study provide an integrated view of the relations between the MAS, the CI and performance, from which are deduced strong interdependencies. In fact, despite the non statistical significance of positive direct relationship between the MAS and the RC, there is strong evidence of the ability of MAS to assist the development of the different dimensions of the IC and therefore the IC as a whole; (ii) it is highlighted the role of MAS as information networks that collect, process and communicate information that influence the development of organizational IC, but also as networks of relationships that support the establishment of conditions for the creation and integration of knowledge; (iii) the study presents an integrated view of the interactions between the various elements of the IC and the underlying dynamics between the three dimensions of IC is expressed in a circular structure. The causal links between MAS and IC elements show how MAS serve this dynamic; (iv) the study also shows that MAS have a positive effect on performance through the mediating effect on SC.

This study has several limitations, in addition to those that derive from the survey method, despite our concerns about the purpose and design of the survey, the population definition and sampling, the survey questions, the accuracy of the data entry and the disclosure and reporting [48]. First, the estimation procedure allowed only partial validation of the proposed model, because one of the relationships in the first set of hypothesis and two in the third block were positive but not significant. Second, the response rate is relatively low. Although the sample size can be defined as tolerable from a statistical point of view we do not exclude some damage in terms of generalization of the conclusions drawn from the data analysis. Finally, it must also be noted that although the accuracy in the definition and construction and measurement of variables, the phenomena investigated in this work are not fully or easily measurable. Moreover, this work did not investigate the similarities or dissimilarities that may exist between companies belonging to different sectors of activity.

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